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INVESTIGATIONS ON LIGHT AND HEAT, MADE AND PUBLISHED WHOLLY OR IN PART WITH
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IX.

CONTRIBUTIONS FROM THE PHYSICAL LABORATORY OF THE
MASSACHUSETTS INSTITUTE OF TECHNOLOGY.

XXVI.—EXPERIMENTS ON THE MELTING PLATINUM
STANDARD OF LIGHT.

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Presented June 16, 1886.

NOTWITHSTANDING the fact that the amount of light emitted normally by a square centimeter of platinum at its point of solidification has been adopted as a standard both by the International Electrical Conference and by the United States National Conference of Electricians, but very few experiments have been made to determine whether it can be made reliable and capable of practical use. An approach toward giving the method a practical form was made by W. Siemens,* who proposed to substitute the light emitted by a given area of platinum at its melting point instead of at its point of solidification, and suggested a means by which with this modification the standard could readily be utilized.

The following experiments resulted from a conference of a portion of the Committee on Standards of Light appointed at the Electrical Conference at Philadelphia in 1884.† They had for their object the ascertaining of a single fact, viz. the amount of the average deviation which would arise in a series of measurements of the light emitted by a strip or wire of platinum of given surface when at the melting point.

A few preliminary experiments were made by the writer, in which a measured length of fine platinum wire, four one-thousandths of an inch in diameter, was placed at one end of the bar of a Bunsen photometer, with a gas-jet shining through a limited aperture at the other end. A current from a small hand Gramme machine was carried through the wire, which was made to glow more and more brilliantly

* Wied. Ann., 1884, vol. xxii. p. 304.

† Messrs. J. Trowbridge, E. C. Pickering, and C. R. Cross.

by increasing the speed of the machine. Following the method of Siemens, the greased disk of the photometer was moved farther and farther from the incandescent platinum, so as to keep the disk uniformly illuminated, until finally melting occurred. The last reading of the position of the disk gave the illuminating power of the wire at melting. An unexpected constancy in the results was found, so that it seemed worth while to make a longer series of such observations, which was done in the following manner. At one end of the bar of a greased-disk photometer 200 centimeters (78.74 inches) long was placed a circular aperture, through which shone the light of an Argand gas-burner. A platinum-wire lamp was constructed, in which a given length of wire was stretched between two fixed knife-edges, and held by clips, thus allowing of speedy adjustment of the wire. The disk used was furnished with two mirrors inclined at 45° in the usual manner, and it was always placed so that the two sides as seen by reflection appeared alike, — a method of measuring much more satisfactory than the one commonly employed with the Bunsen photometer. The length of wire used was measured between the edges when cold, and allowed to expand freely. An attempt was made to use a slit of given length in front of a longer wire, which was abandoned owing to errors arising from inequality in the length of that portion of the wire whose light passed through the slit when the wire expanded. The use of a small weight stretching the wire tight, as suggested by Professor Pickering and employed by him in a small lamp, presents some advantages, but was discarded from fear of elongating the wire and so causing it to break before complete fusion was reached. Melting was brought about by the use of a slide-resistance of German-silver wire in circuit with the platinum wire and a dynamo machine. The variable resistance of the slide was lessened until the platinum wire melted, the photometer-disk being meanwhile moved repeatedly, its final reading giving the light emitted by the platinum in terms of the light emitted by the aperture opposite.

No attempt has been made in these experiments to determine the absolute illuminating power of the wire, but only to ascertain whether ordinary commercial platinum wire has any practical value for use as a primary or a secondary standard.

Two different sizes of wire were used, whose diameters were .004 in. and .006 in. respectively. Wire from two different makers was also used, ordinary wire drawn without special care being taken because of its availability. The length used was always the same when cold, viz. two inches. A very large number of measurements were

made, chiefly by Messrs. F. H. Crane and H. E. H. Clifford, students in the laboratory, and careful and accurate observers.

Five sets of observations on successive fusions of wire were made by each observer, and the mean taken. The mean and the average deviation from the mean of a long series of such sets were then found. The tables give the results of the measurements. In all cases the distance between the opposite lights is 78.74 in. (200 cm.), and the diameter of the aperture in front of the gas flame $\frac{2}{3}$ in. The recorded distances are measured from the aperture.

In order to give an idea of the degree of concordance of the separate individual readings, the following sets (Table I.) are taken at random. The numbers given are the final positions of the disk, in each experiment, in inches.

TABLE I.

Diameter of wire = .004 in.

Observer <i>M.</i>	Observer <i>N.</i>
43.7	43.6
43.6	43.7
43.7	43.7
43.6	43.5
43.5	43.8
Mean 43.62	Mean 43.66

A change of 0.1 in. corresponds to an absolute change of 0.007 in illuminating power of opposite light = 1.1 per cent.

Diameter of wire = .006 in.

Observer <i>N.</i>	Observer <i>N.</i>
37.7	37.4
37.8	37.2
37.4	37.4
37.2	36.8
37.2	37.2
Mean 37.46	Mean 37.20

A change of 0.1 in. corresponds to an absolute change of 0.01 in illuminating power of opposite light = 1.0 per cent.

Table II. is given at length as indicating more clearly the variations among consecutive sets of measurements. I. P. denotes the illuminating power of the platinum wire in terms of that of the opposite light. The average deviation of I. P. is the change in this quantity

produced by an increase in the scale-reading equal to the average deviation in inches.

TABLE II.

Diameter of wire = .004 in. Sample A.

Averages of 5 Experiments. Observer <i>M</i> .	Averages of 5 Experiments. Observer <i>N</i> .
43.6	43.7
43.7	43.5
43.6	43.5
43.7	43.4
43.5	43.4
43.6	43.6
43.5	43.3
43.6	43.6
43.6	43.2
43.5	43.7
Mean 43.59	Mean 43.49

Average deviation .06 in.

Average deviation .13 in.

I. P. = .650.

I. P. = .657.

Average deviation I. P. = .004.

Average deviation I. P. = .009.

Tables III. and IV. give the means of the various sets of experiments. Column 1 shows the sample used; 2, the mean of the series taken; 3, the number of observations from which the mean is derived; 4, the observer; 5, the illuminating power; 6, the average deviation in inches; and 7, the average deviation in terms of the illuminating power. It will be seen that the maximum average deviation in I. P. for the finer wire is 1.7 per cent, and for the coarser wire 1.6 per cent of the total value.

TABLE III.

Diameter of wire = .004 in.

Sample.	Mean.	Number of Obs.	Observer.	I. P.	Av. Dev. Inches.	Av. Dev. I. P.
A	43.59	50	<i>M</i>	.650	.06	.004
A	43.49	50	<i>N</i>	.657	.13	.009
B	43.77	50	<i>N</i>	.638	.11	.007
B	43.70	50	<i>M</i>	.643	.16	.011
B	44.86	50	<i>N</i>	.570	.18	.010
A	45.16	50	<i>N</i>	.553	.12	.007
A	43.72	50	<i>N</i>	.641	.12	.007

TABLE IV.

Diameter of wire = .006 in.

Sample.	Mean.	Number of Obs.	Observer.	I. P.	Av. Dev. Inches.	Av. Dev. I. P.
A	35.37	20	N	1.504	0.15	.024
A	37.19	30	N	1.249	0.14	.019

In order to determine the possible accuracy of setting the photometer disk, several series of readings (Table V.) were taken, in which two apertures through which a gas-flame shone were balanced against each other. These readings were taken with apertures of different sizes, in order to test the accuracy of setting in different parts of the scale; that is, for different relative brilliancies of the lights. Series 3 and 4 were taken so as to bring the disk in the same position as that which it occupied with the .004 in. and .006 in. platinum wire.

TABLE V.

Series.	Number of Observations.	Mean.	I. P.	Av. Dev. Inches.	Av. Dev. I. P.
1	50	31.35	2.286	.076	.019
2	50	31.40	2.273	.054	.012
3	50	43.92	0.628	.042	.003
4	50	36.48	1.342	.044	.005

It appears that the average deviation of the different readings when the opposite illuminated apertures were balanced against each other is in general considerably less than that of the readings with the melting wire. The maximum average deviation of I. P. is 0.8 per cent of its total value; the minimum value is about half as great.

Marked differences in the illuminating power of the platinum wire of the same diameter on different days were observed, contrasting strongly with the uniformity of the results of successive measurements. This undoubtedly arose from changes in the quality, and hence in the illuminating power, of the gas, as the height of the flame was kept constant. In future experiments I hope to obtain a more constant standard by using a moderator lamp with aperture, or else by employing the pentane burner.

A consideration of the results given in Tables III. and IV. shows that the light emitted by a filament of commercial platinum at the

melting point is quite constant in successive measurements, and it appears to present greater uniformity than many of our commercial standards. There is little doubt, moreover, that by the use of a wire longer, and perhaps of larger diameter, the results would be improved, as there would be less liability to error from the cooling of the ends of the wire by contact with the metal supports (an action, however, which can easily be removed altogether), and from accidental minute inequalities in the length of the wire used. It would also be desirable to use platinum of better quality than is usually found in commercial wire, and to have special care exercised in drawing to insure accurate cylindricity.

It is also evident that such a wire as I have used cannot at best be employed except as a secondary standard, since the ratio of the luminosities of the two gauges of wire employed is not at all in the ratio of the projection of their surfaces.

Still further, a difficulty may arise in the use of a melting platinum wire or strip even as a secondary standard from variations in the physical condition of the metal due to cracking, occluded gases, or other causes. No certain evidence of this was observed with the samples of wire employed, but I am not at all sure that it may not occur with different specimens of commercial wire. From a few preliminary experiments of a series still in progress it appears probable that successive heating and cooling, or continued heating of the wire even under ordinary atmospheric pressure, tend slightly to raise its point of fusion, an action which Edison has shown* to be carried to an extreme degree when continued heating in vacuo is employed. Thus, in one experiment the wire was heated by the current and cooled from one to ten times, and then carried up to its melting point, photometric readings being taken as in previous experiments, with the following results. The wire was .006 inches in diameter. Each value given is the mean of five measurements.

	Mean Reading.
Without reheating	37.65
Reheated once	37.42
“ twice	37.42
“ 3 times	37.62
“ 4 “	37.26
“ 5 “	37.06
“ 10 “	37.26

* Proceedings of American Association, 1879, vol. xxviii. p. 173.

The lesser readings indicate greater luminosity of the melting wire.

In another experiment, the wire in its ordinary condition melted when the reading (mean of 5 measurements) was 37.8 in. After annealing in a Bunsen flame, the mean reading at melting (for five experiments) was 37.2 in. After heating to a yellow heat by passing a current of electricity through it for half an hour, the reading at melting (mean of 23 measurements) was 36.9 in.

If further experiment should show conclusively that the light emitted by melting platinum is variable beyond narrow limits, it is clear that any photometric standard based on the luminosity of *melting* platinum will present no advantage over those standards now in ordinary use, unless specially prepared platinum freed from gases and consolidated by Edison's process of heating in vacuo is found to be available. Probably solidifying platinum, provided its point of solidification is sufficiently definite, would be free from this objection, although this can hardly be accepted without experimental proof.

ROGERS LABORATORY OF PHYSICS,
June, 1886.